Resurrecting the Weak Credibility Hypothesis in Models of Exchange-Rate-Based Stabilization

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ABSTRACT

We analyze how weak credibility affects the volatility of consumption spending in a model of exchange-rate-based stabilization that allows for both durable and nondurable goods. The inclusion of durables greatly improves the explanatory power of the weak credibility hypothesis. The hypothesis can account for the main qualitative properties of the boom-bust cycle provided the elasticity of durables expenditure with respect to Tobin's q is greater than the intertemporal elasticity of substitution. Moreover, the quantitative effects are very large. In numerical simulations based on conservative assumptions about the expenditure share of durables (20%) and wealth effects (none), aggregate consumption increases 12-28% and the real exchange rate appreciates 24-26% when the crawl decreases from 100% to zero for three years. In variants of the model that incorporate supply effects, the consumption boom is equally strong but appreciation of the real exchange rate rises to 30-40%.

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Stabilization programs that formally announce a lower rate of crawl of the currency, once common in less developed countries (LDCs), are now comparatively rare. Nevertheless research on exchange-rate-based stabilization (ERBS) continues to occupy a special place in development macroeconomics. In part this reflects the fact that elements of ERBS are very much present in other stabilization frameworks. LDC central banks often try, for example, to counteract terms of trade shocks, aid surges, and unexpected capital inflows by "leaning against the wind" in the foreign exchange market. The attempt to manage the path of the exchange rate is not called ERBS because it is not part of a larger program that declares a new policy regime. But if the public believes the intervention is unsustainable and that the rate of crawl will soon change, then leaning against the wind is just non-credible ERBS under a different name. ERBS is still an active player in the policy world, albeit in a different form.

The other, more important reason for the ongoing study of ERBS is that the potential payoff is large. ERBS is one of the few unifying experiments in the sprawling field of development macroeconomics. More than twenty LDCs in Latin America, Africa, the Middle East, and East Asia have adopted ERBS programs at one time or another in the past forty years. In the great majority of cases, the announcement of the program has been followed by large current account deficits, large capital inflows, a pronounced surge in consumption spending, and persistent, strong appreciation of the real exchange rate. This set of stylized facts is remarkably robust to date, geographic location, position on the development spectrum, and the mix of policies supporting the lower rate of crawl. Finding a satisfactory explanation for the ERBS syndrome should tell us a great deal therefore about the correct model structure for LDC macroeconomies; the challenge posed by the stylized facts in ERBS episodes disciplines development macrotheory in the same way that the need to explain the U.S. business cycle disciplines developed country macrotheory.

Calvo and Vegh (1993, 1994a) launched the modern ERBS research program with the publication of two seminal papers that focused on weak credibility as the underlying source of the consumption boom. The link between credibility and spending arises when holdings of real money balances affect the cost of consumption. Calvo and Vegh assumed specifically that money demand is governed by a cash-in-advance constraint and that the country

operates in a perfect world capital market. In this setup, a temporary (i.e., non-credible) reduction in the rate of crawl lowers the price of consumption today relative to the price of consumption in the future. Intertemporal substitution then leads to a consumption boom and a current account deficit financed by private capital inflows. The bill for high spending during the boom phase is paid in perpetuity in the post-ERBS period: when the policy collapses, consumption drops below its previous level and the country runs a trade surplus year in and year out to cover higher interest payments on the external debt.

While the weak credibility hypothesis exercises a strong intuitive appeal, its explanatory power is thought to be limited by the fact that the intertemporal elasticity of substitution is low in LDCs. In the Calvo-Vegh model, for example, the peak increase in real consumption is a modest 1-3% when the intertemporal elasticity lies between .20 and .50.[1] Consistent with this, Reinhart and Vegh (1995a) and Mendoza and Uribe (1996) found that the weak credibility hypothesis predicts increases in consumption only 10-20% as large as the increases observed in the southern cone tablitas and other ERBS episodes. Thus both theory and empirical tests seem to argue that the weak credibility hypothesis cannot deliver strong quantitative effects (Agenor and Montiel, 1996, p.353).

Since the Calvo-Vegh papers first appeared, theoretical research has moved on to investigate the properties of models with assorted wealth and supply-side effects in the hope of achieving a better fit with the stylized facts. This hope has not been borne out. After surveying the literature and conducting additional independent analysis, Rebelo and Vegh (1995) conclude that, even when combined for maximum impact, the proposed effects cannot account for the quantitative magnitude of the consumption boom and real exchange rate appreciation seen in ERBS programs. The bottom line in Uribe (2002), the most recent attempt to secure strong wealth/supply effects, is equally discouraging.[2]

Repeated failure has taken a toll. New research on ERBS now has to battle uphill against the perception that "everything has been tried and nothing works." This is unfortunate because the weak credibility hypothesis was never given a fair hearing. Rebelo and Vegh (1995) and Reinhart and Vegh (1995) were careful to note that the spending boom might be much stronger in models that incorporate durable consumer goods. Certainly there is abundant casual evidence to support this conjecture. According to case studies and Calvo and

Vegh's (1999) stabilization time profiles, the boom-bust cycle is driven by the tremendous expansion and subsequent collapse in durables purchases. But despite the "hints" in the data, durables have not figured in most ERBS models. The sole exception is De Gregorio, Guidotti, and Vegh's (1998) elegant analysis of the "bunching" pattern in durables spending when purchases follow a S-s rule. Their model, however, abstracts from nondurables consumption, treats wealth effects as largely exogenous, and assumes ERBS is permanent and fully credible. It is too stylized therefore to confront with the data or with the competing hypothesis that the consumption boom stems from weak credibility.

This paper reevaluates the weak credibility hypothesis in a variety of models that accomodate both durable and nondurable consumer goods. We start with a simple fixed-output one-sector model that permits the derivation of sharp analytical results. In the simple model, two key elasticities, the intertemporal elasticity of substitution (τ) and the q-elasticity of durables spending (Ω), command the spotlight. When imperfect credibility of the announced crawl causes intertemporal prices to vary, the former controls the response of nondurables consumption and the latter the response of durables expenditure. Many of the qualitative properties of the consumption path depend therefore on whether Ω is larger or smaller than τ. We demonstrate that $\Omega > \tau$ is sufficient for: (i) durables spending to increase more than nondurables expenditure on impact; (ii) aggregate consumption to rise more than in the counterfactual scenario where all consumption is nondurable; (iii) durables spending to decrease more than nondurables consumption at the time of the policy reversal and (iv) durables spending to overshoot its lower steady-state level during the ERBS period. These results — especially overshooting — are consistent with durables being the most volatile component of aggregate consumption and with the stylized fact that durables spending leads in both the boom and the bust phases of the ERBS cycle.

Following the pen-and-paper theoretical analysis, we calibrate the model and present solutions for the global nonlinear saddle path when the rate of crawl decreases from 100% to zero for three years. The numerical results confirm that weak credibility triggers a huge, double-digit spending boom. Aggregate consumption increases 9-18% in the first year, rising to 12-28% by the end of ERBS. Throughout, most of the heavy lifting is done by the smallest component of expenditure: durables comprise only 20% of consumption but account for 70-

90% of the increase in total spending.

The analysis of the simple benchmark model lays the groundwork for the development of progressively more elaborate models and a wider investigation of the stylized facts in the second half of the paper. The first of the more elaborate models fixes a problem with the slope of the consumption path. The simple benchmark model predicts that the post-jump path of consumption is flat for the first half of the ERBS program and positively sloped in the second half. In reality, consumption either increases continuously or follows a hump-shaped path, with the downturn coming in the last 6-12 months of the program. Accordingly, we investigate whether habit formation improves the fit with the data. It does, but only if habit enters the utility function in the right way. Familiar, off-the-shelf specifications create incentives to smooth the large jumps in consumption at the beginning and the end of ERBS. This produces a nice hump-shaped path for nondurables consumption but has little effect on the dynamics of durables *spending* or aggregate consumption expenditure because most of the service flow of a durable good is consumed subsequent to the date of purchase. The diagnosis of the problem, however, also points to the solution: let habit affect the planning costs associated with the purchase of a durable good so that the agent seeks to smooth the path of durables spending. This works splendidly. When habit affects durables spending as opposed to the utility flow from consumption, the path of aggregate consumption *expenditure* is hump-shaped and the turning point comes at the right time, 6-9 months before ERBS collapses. Moreover, in contrast to the results in Uribe (2002), there is no marked tradeoff between the slope of the consumption path and its height. Depending on the specification, the peak increase in aggregate consumption is either about the same or *twice as high* as in the model without habit formation.

While a one-sector model with constant output is a useful device for thinking about the elements needed to explain the boom-bust cycle in consumption, it precludes analysis of other important stylized facts — most notably the impact of ERBS on the path of the real exchange rate — and of alternative theories of ERBS that appeal to supply-based wealth effects. To remedy this, we add a nontradables sector, a labor-leisure choice, and private investment to the model and compare outcomes with and without supply effects for temporary/noncredible vs. permanent/credible programs. The results further strengthen the case for resurrecting

the weak credibility hypothesis. When there are no supply effects, the consumption boom peaks at 17-22% and the real exchange rate appreciates 24-26%. Augmenting the model with supply effects produces even better numbers. In our preferred specification, the consumption boom is equally strong but appreciation of the real exchange rate rises to 30-40%. In other runs, the consumption boom increases to 25-35% without diminishing appreciation of the real exchange rate (which stays in the 20-25% range). Supply effects are limited, however, to a secondary role. When stabilization is credible, their quantitative kick is bigger but insufficient to compensate for the absence of intertemporal substitution in durables spending. The consumption boom peaks at a modest 5% and the real exchange rate appreciates only 3-8%. Future research may overturn this conclusion, but, for now, the weak credibility hypothesis stands alone as the only hypothesis that explains the stylized facts associated with ERBS.

The rest of the paper is organized into eight sections. The first three sections develop theoretical and numerical results for the stripped-down benchmark model. Section 4 investigates the extent to which different specifications of habit formation improve the fit between the data and the model's predicted paths for nondurables consumption, durables spending, and aggregate consumption. Sections 5-7 analyze the full range of stylized facts and the merits of competing hypotheses of ERBS in the unabridged model that incorporates nontraded goods, supply-based wealth effects, and habit formation. The final section contains concluding remarks.

1. A Simple One-Sector Model

In this section we analyze a simple model of a small open economy in which all consumer goods are tradable, domestic output is fixed at Q, the inflation rate equals the rate of crawl of the currency π, and the private sector divides its wealth between money m and a tradable bond b that pays the world market interest rate r. Our objective is to derive a set of core propositions which establish a presumption that the numerical results in later more realistic and more complicated models are robust.

We lay out the model in stages, starting with the specification of financial markets and the transactions technology.

Financial Markets and the Transactions Technology

Bonds are bought and sold in a perfect world capital market. The nominal interest rate i is tied down therefore by the interest parity condition:

$$i = r + \pi. \tag{1}$$

Money is held to reduce transactions costs. These costs enter the budget constraint [see equation (4) below] via the term $(C+S)L[m/(C+S)]$, where L is decreasing and strictly convex in the ratio of money balances to the sum of spending on nondurables consumption C and gross new durables purchases S ($L' < 0$, $L'' > 0$).

The Private Agent's Optimization Problem

All economic decisions in the private sector are controlled by a representative agent who possesses an instantaneous utility function of the form $U(C,D) - R(\dot{D}/D)D$, where a dot signifies a time derivative and $U(\cdot)$ is increasing and strictly concave in C and D. The $R(\cdot)D$ component of the utility function is taken from Bernanke (1985). It introduces a friction that prevents durables purchases from being absurdly volatile. As Bernanke emphasizes, new durables purchases are not easy or automatic: in contrast to spending on nondurables, the decision to buy a durable often involves time-consuming search and careful deliberation. The utility cost of worrying and lost leisure time is assumed to be increasing, symmetric, and convex in net purchases of durable goods: $R(0) = 0, R' \gtrless 0$ as $\dot{D} \gtrless 0$, and $R'' > 0$.

After imposing interest parity and defining $A \equiv m + b$ to be total wealth, the private agent's optimization problem may be written as

$$\underset{(C,S,m,b)}{Max} \quad \int_0^\infty [U(C,D) - R(S/D - \delta)D]e^{-\rho t}dt, \tag{2}$$

subject to

$$A = m + b, \tag{3}$$

$$\dot{A} = Q + \tilde{g} + rb - (C+S)\left[1 + L\left(\frac{m}{C+S}\right)\right] - \pi m, \tag{4}$$

$$\dot{D} = S - \delta D, \tag{5}$$

where ρ is the time preference rate; D is the stock of durables; $\tilde{g} = g + (C+S)L$ is lump-

sum transfers; and δ is the depreciation rate of the durable good. Transfer payments are split into two components: government transfers, g, and rebated profits of firms that supply transactions services, $(C+S)L$. The latter component ensures that transactions costs wash out in the budget constraint. This eliminates a potentially dubious income effect. With the income effect removed, variations in the cost of liquidity influence spending only insofar as they alter the price of current vs. future consumption.

The Maximum Principle furnishes the necessary conditions for an optimum. These consist of

$$
\begin{aligned}
U_C(C,D) &= \omega_1(1+L-L'm/X), && (6)\\
-L' &= r+\pi, && (7)\\
\omega_2 &= \omega_1(1+L-L'm/X)+R'(S/D-\delta), && (8)\\
\dot{\omega}_1 &= \omega_1(\rho-r)=0 \quad \text{for} \quad \rho=r, && (9)\\
\dot{\omega}_2 &= \omega_2(\rho+\delta)+R-R'S/D-U_D, && (10)
\end{aligned}
$$

where $X \equiv C+S$ and ω_1 and ω_2 are the multipliers attached to the constraints (4) and (5). Equation (6) says that the marginal utility of nondurables consumption equals the shadow price of wealth multiplied by the *effective* price of consumption $(1+L-L'm/X)$, while (7) requires money to earn the same return at the margin as bonds. In equation (9) we have assumed $\rho = r$ in order to abstract from trends in saving. Finally, equations (8) and (10) define a Tobin's q model of durables purchases in which $\omega_2/\omega_1(1+L-L'm/X) = \omega_2/U_C$ is the ratio of the demand price (or shadow price) of a durable to its supply price (unity) and R' captures additional adjustment costs incurred by increasing S a small amount.

Path of the Crawl

The path for the crawl is

$$
\pi = \begin{cases} \pi_1 < \pi_o \quad \text{for} \quad 0 < t < T \\ \pi_o \quad \text{for} \quad t > T \end{cases} \tag{11}
$$

ERBS commences with an announcement that the rate of crawl will be reduced from π_o to π_1 and maintained at the lower level forever more. This proves false. Forever more lasts

only until year T, at which time the government aborts the program and raises the crawl to its original level.

The Public Sector Budget Constraint

Money is injected into the economy whenever the central bank accumulates foreign exchange reserves k or runs the printing press to finance the fiscal deficit. Assuming reserves are invested in the tradable bond, the consolidated public sector budget constraint reads

$$\dot{k} = rk + \pi m + \dot{m} - g. \tag{12}$$

Fiscal policy is passive. Crucially, the reduction in the crawl is not supported by a cut in real transfer payments.[3] When the program fails and π returns to its original level, g adjusts only enough to offset any changes in the sum of interest income and revenue from the inflation tax $(rk + \pi m)$.

Net Foreign Asset Accumulation and the Current Account Balance

Summing the public and private budget constraints produces the accounting identity that net foreign asset accumulation equals the current account surplus, viz.:

$$\dot{Z} = Q + rZ - C - S, \tag{13}$$

where $Z \equiv k + b$.

Functional Forms

To obtain concrete analytical results and prepare the model for calibration, we assume

$$\begin{aligned} U(C,D) &= \frac{C^{1-1/\tau}}{1-1/\tau} + a_o \frac{D^{1-1/\tau}}{1-1/\tau}, \quad a_o, \tau > 0, \\ R(S/D-\delta) &= x\frac{(S/D-\delta)^2}{2}, \quad x > 0, \\ L\left(\frac{m}{C+S}\right) &= h\left(\frac{m}{C+S}\right)^{1-1/\beta}, \quad h > 0, \quad 0 < \beta < 1, \end{aligned}$$

where τ is the intertemporal elasticity of substitution and β is the interest elasticity of money demand. These are familiar functional forms. The utility function is isoelastic and separable in nondurables consumption and the service flow from durables, while deliberation costs are

a quadratic function of new durables purchases. The specification of transactions costs is the same as in Reinhart and Vegh (1995) and Uribe (2002).

The assumption of a separable utility function is not particularly restrictive in the current model or the models that follow in Sections 3 and 4. We have also derived results, however, for the nonseparable case. These can be found in a longer version of the paper available at http://mypage.iu.edu/~ebuffie.

2. Solving the Model for Small Changes

It is possible to derive analytical results when the reduction in the crawl is small. This is worth doing. Although the final word rests with the solution for the global nonlinear saddle path, a lot can be learned about the general nature of the dynamics by solving the model for differential changes.

We start by manipulating the first-order conditions. Differentiate (8) with respect to time and substitute for $\dot{\omega}_2$ from (10). Since m/X and U_C are constant during intervals where π is constant, we get

$$\begin{aligned} \dot{\omega}_2 &= R''\left(\frac{\dot{S}}{D} - \frac{S}{D^2}\dot{D}\right), \\ \Longrightarrow \frac{R''}{D}\dot{S} &= (\rho+\delta)U_C + (\rho+\delta-S/D)R' + \frac{R''S}{D^2}(S-\delta D) + R - U_D. \end{aligned} \tag{14}$$

Equations (5) and (14) are a self-contained sub-system in S and D. (U_C is constant in the first term.) Linearizing (14) around a stationary equilibrium $(\bar{S}, \bar{D})$ and invoking the functional forms for $U(\cdot)$ and $R(\cdot)$ produces

$$\dot{S} = (\rho+\delta)[(S-\bar{S}) - \delta(D-\bar{D})] + \frac{\rho+\delta}{\tau x C^{1/\tau}}(D-\bar{D}), \tag{15}$$

$\tilde{x} \equiv xC^{1/\tau}$ determines how fast marginal deliberation costs, measured in units of the consumption good, increase with the growth rate of durables purchases.[4] To relate this to observable magnitudes, write (8) as $1 + \tilde{x}(S/D - \delta) = q$,where $q \equiv \omega_2/U_C = \omega_2 C^{1/\tau}$ is Tobin's q, the ratio of the demand price of a durable to its supply price (unity). Differentiating

with respect to S and q yields

$$\tilde{x}\frac{S}{D}\frac{dS}{S} = q\frac{dq}{q}.$$

Define $\Omega \equiv (dS/dq)q/S$ to be the elasticity of durables spending with respect to Tobin's q. Evaluated at a steady state (where $S/D = \delta$ and $q = 1$), $\Omega = 1/\delta\tilde{x}$. The linearized system is thus

$$\begin{bmatrix} \dot{S} \\ \dot{D} \end{bmatrix} = \begin{bmatrix} \rho+\delta & (\rho+\delta)\delta(\Omega/\tau - 1) \\ 1 & -\delta \end{bmatrix} \begin{bmatrix} S-\bar{S} \\ D-\bar{D} \end{bmatrix}, \tag{16}$$

Since the system's eigenvalues are opposite in sign, the steady state is a saddle point.

During the ERBS phase, the dynamics are governed by a nonconvergent path of the system associated with the low rate of crawl π_1. For this phase, (16) gives

$$S(t) - S_1 = (\lambda_1+\delta)h_1e^{\lambda_1 t} + (\lambda_2+\delta)h_2e^{\lambda_2 t}, \quad t < T, \tag{17}$$

$$D(t) - D_1 = h_1e^{\lambda_1 t} + h_2e^{\lambda_2 t}, \quad t < T, \tag{18}$$

where $\lambda_1 > 0$ and $\lambda_2 < 0$ are eigenvalues; h_1 and h_2 are constants determined by boundary conditions; and (S_1, D_1) is the stationary equilibrium paired with π_1.

After the policy reversal at time T, the economy follows the saddle path that leads to the new long-run equilibrium (S_2, D_2). On the convergent path, the term involving the positive eigenvalue drops out:

$$S(t) - S_2 = (\lambda_2+\delta)h_3e^{\lambda_2 t}, \quad t \geq T, \tag{19}$$

$$D(t) - D_2 = h_3e^{\lambda_2 t}, \quad t \geq T. \tag{20}$$

h_3 is another constant. Also, we have exploited the fact that for small changes the negative eigenvalue is the same as in (17) and (18).

Turning back to the first-order conditions in (6)-(10), observe that $U_D/U_C = (C/D)^{1/\tau} = \rho + \delta$ across steady states. This implies

$$C_i - C_o = \frac{C_o}{D_o}(D_i - D_o), \quad i = 1, 2. \tag{21}$$

There are two more steps in the solution procedure: (1) derive the five boundary con-

ditions that pin down D_1, D_2, and h_1-h_3 ($S_i = \delta D_i$ takes care of durables spending); (2) plug the solutions into (17)-(20) and extract conditions that delineate the path of spending. Both steps involve a good deal of tedious algebra. In a supplementary appendix (available upon request), we show that

$$\hat{S}(0), \hat{C}(0) > 0, \quad \hat{S}(T), \hat{C}(T) < 0, \quad D_1 > D_o > D_2,$$

and prove

Proposition 1 *When the utility function is separable between durables and nondurables, $\Omega > \tau$ is necessary and sufficient for durables spending to (i) increase more than nondurables spending at the start of ERBS [$\hat{S}(0) > \hat{C}(0)$], (ii) decrease more than nondurables spending at the time of the policy reversal [$\hat{S}(T) < \hat{C}(T) < 0$], and (iii) overshoot and remain below its steady-state level throughout the post-ERBS period [$S(t) < S_2,\ t > T$].*

These results agree with intuition. When the government lowers inflation to π_1, the demand for real money balances rises and the effective price of consumption falls. [The term $1 + L - L'm/X$ decreases by $-L''d(m/X) = (m/X)d\pi$ in (6) and (8).] Since the decrease in inflation is temporary, the agent substitutes from future consumption to current consumption. The scope for intertermporal substitution in nondurables consumption depends on concavity of the utility function in C, which is fixed by τ. Concavity of the utility function in D has little effect on the path of S, however, because changes in spending do not significantly alter the accumulted stock in the short run and because consumption of the service flow of a durable good occurs over an extended period of time. Intertemporal substitution in durables *spending* is limited instead by rising marginal deliberation costs as measured by $\tilde{x}$. The smaller this friction the larger is Ω ($\Omega = 1/\delta\tilde{x}$). Consequently, for $\Omega > \tau$, the response of durables to intertemporal variations in the effective price of consumption is stronger than the response of nondurables.

Figure 1 shows the complete transition path. The $\dot{S} = 0$ and $\dot{D} = 0$ schedules determine which way the north-south and east-west directional arrows point during the ERBS phase, while A_iA_i is the saddle path associated with (S_i, D_i). In the lower quadrant, we use equation (21) to track the path of nondurables consumption.

When ERBS is announced, C jumps to C_1 and S jumps to a point above A_1A_1 (see the supplementary appendix). After the initial jumps, C stays at C_1 until ERBS collapses while

S either rises continously or follows a shallow U-shaped path. The logic behind the flat path of C is straightforward. To repeat, the effective price of consumption $(1 + L - L'm/X)$ is constant as long as inflation is constant. Thus, in between jumps at times of regime changes, the marginal utility of nondurables consumption remains. In the case of a separable utility function, U_C is independent of D, so the path is flat.

The dynamics for durables spending are more intricate but also readily explicable. Absent adjustment costs, private agents would concentrate all purchases in the moment before the effective price of consumption rises at time T (Calvo, 1988). With adjustment costs, it is desirable to shift some expenditure to earlier periods. Hence $S_o < S(0) < S(T^-)$. Following the initial jump, the incentive to increase S battles against diminishing marginal utility of durables consumption. If the latter effect dominates, the transition path includes a period of decreasing expenditure. This phase is strictly transitory, however. Since it is optimal to accelerate purchases as t approaches T, the path always crosses the $\dot{S} = 0$ schedule before the program fails. In the numerical simulations, the crossing point is typically around the middle of the second year (when $T = 3$).

The consumption spree and ERBS end at the same moment. When the crawl abruptly increases at T, spending plummets across-the-board. The diagram suggests and the numerical simulations will shortly confirm that the collapse is concentrated in durables purchases: C jumps to C_2 and is constant thereafter, but S *overshoots* S_2. Durables lead in the sudden crash just as they lead in the boom.[5] Over the whole cycle, the gyrations in aggregate consumption mirror the volatile dynamics of durables expenditure.

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Taking stock, how much has been accomplished in Proposition 1 and Figure 1? Certainly the weak credibility hypothesis has regained some of its swagger. Given the tremendous volatility of durables spending in ERBS programs, there is not much doubt that Ω is considerably larger than τ and that the boom-bust cycle in durables expenditure drives the boom-bust cycle in aggregate consumption. On its own, however, this is not enough to rehabilitate the hypothesis. The analytical results were derived for small changes. As such, they are only *suggestive* of strong quantitative effects. Confirmation is needed from numeri-

cal simulations that the predicted paths for durables expenditure and aggregate consumption lie within shouting distance of the big numbers seen in the data.

3. Calibration of the Model and Numerical Results

To calibrate the model, we set

$$\begin{aligned} \mu_o &= .10, \quad \beta = .50, \quad \gamma_o = .80, \quad \delta = .10, \quad T = 3, \\ \pi_o &= 1, \quad \pi_1 = 0, \quad r = .05, \quad \tau = .25, .50, \quad \Omega = 5, 10. \end{aligned}$$

The ratio of money balances to aggregate spending (μ) is 10%. This is a conservative choice closer to the ratio of money to GDP than to the ratio of money to private consumption. It is intended to counteract any bias toward a strong consumption boom caused by the absence of a nontradables sector. With respect to the other choices:

- *Elasticity of money demand with respect to the interest rate* (β). Reinhart and Vegh (1995a), Rossi (1989), and Arrau et al. (1995) have estimated money demand functions of the type employed in our model. The value assigned to β is almost the same as the average of their estimates for Argentina, Brazil, Mexico, Chile and Uruguay.[6]
- *Consumption share of durables* ($1 - \gamma_o$). The share of durables in aggregate spending is $S/(C + S)$. A figure close to this can be computed from the United Nations National Income Accounts. For a broad definition that includes semi-durables, the share lies in the .18-.22 range: .223 for Mexico (2000), .179 for Colombia (1998), .180 for Bolivia (1992), .203 for the Philippines, and .217 for S. Africa (2001) and S. Korea (2002). The value in the model (.20) is the average of the values for Mexico and Colombia.
- *Depreciation rate for durables* (δ). The Central Statistical Office of Great Britain and the U.S. Department of Commerce estimate the service life to be ten years for major appliances, cars, and other vehicles (Williams, 1998). We used this figure to fix δ. (There are no data for LDCs.)
- *Length of the ERBS program (T).* The low-crawl period lasts three years. Three is a popular choice in the literature and close to the average value in Calvo and Vegh's (1999) dataset for major ERBS episodes.
- *Rate of crawl before vs. during ERBS* (π_o, π_1). The numerical simulations cut the rate of crawl from an initial value of 100% to zero during ERBS. This is larger than the reductions in the Chilean and Uruguayan tablitas but far smaller than the reductions in the Argentine tablita, Mexico's Solidarity Pact, or Argentina's Convertibility Plan.
- *Real interest rate* (r). Reinhart and Vegh (1995a) peg the world market real interest rate at 3%. Burstein et al. (2001) and Rebelo and Vegh (1995) opt for 4.1%, while Uribe

(2002) prefers 6.5%. We compromise on 5%, a value inbetween the long-run real returns paid by U.S. stocks and treasury bonds.

- *Intertemporal elasticity of substitution* (τ). The low and high values for the intertemporal elasiticity of substitution are in line with estimates for LDCs, most of which place τ somewhere between .20 and .50 (Ogaki et al., 1996; Agenor and Montiel, 1996, Table 10.1).
- *Elasticity of durables spending with respect to Tobin's q* (Ω). Baxter (1996) sets Ω at 200. Baxter and Crucini (1993) and Rebelo and Vegh (1995) choose 15 in models where the durable good is physical capital. 200 and 15 appear to be a pure guesses. (Our own literature search for information about Ω proved fruitless.) We restrict Ω to much lower values but still get tremendous variation in durables expenditure over the ERBS cycle.

The numerical solutions in the next section report results for the global nonlinear saddle path. The solutions were generated by an innovative shooting algorithm that surmounts the unit root problem generic to models that postulate an exogenous world market interest rate. (In continuous time, the unit root shows up as a zero eigenvalue.) See Atolia and Buffie (2009) for a detailed discussion of the algorithm and links to a set of downloadable programs.

3.1 Numerical Results

Figure 2 shows the percentage deviations of nondurables consumption, durables spending, and aggregate consumption ($C + S$) from their initial values. In the figure for aggregate consumption, the dashed line is the path when all consumption is nondurable. The vertical distance between this line and the actual path reflects the impact of durables expenditure at each point in the cycle.

What stands out in a quick pass through the figures are the big numbers for aggregate consumption and durables spending. The peak increase ranges from 12% to 27% for aggregate consumption and from 48% to 104% for durables. Furthermore, the "fit" between the numerical results and the stylized facts pertaining to the composition of consumption growth and the volatility of durables expenditure is remarkably good. In the panel regressions reported by DeGregorio et al. (1998), annual growth of durables spending averages 21% for the first three years, with the 95% confidence interval bracketing 8.5% - 33.7%.[7] The point estimate of 21% is 3.5 times larger than the estimate for total consumption growth. By comparison, in the cases covered by Figure 2, the peak increase in durables spending is 3-4

times larger than the peak increase in aggregate consumption and the average growth rate for durables ranges from 14% to 27%. The numbers are also close for the bust phase of the cycle. DeGregorio et al.'s alternative point estimates have durables expenditure plunging 21-72% (relative to the pre-ERBS trend line) in the year after ERBS collapses. The range in our simulations is -31% to -71%.

These strong results stem from the assumption that Ω, the q-elasticity of durables spending, is large both in absolute value and relative to τ, the intertemporal elasticity of substitution. Recall from the analysis in Section 2 that Ω controls intertemporal substitution in durables purchases while τ controls intertemporal substitution in nondurables consumption. In Figure 2, $\Omega = 5$-10 and the ratio Ω/τ varies from 10 to 40. It follows almost directly from the calibration of the model that a temporary reduction in the crawl will trigger a powerful consumption boom and that durables expenditure will fluctuate much more than nondurables consumption over the ERBS cycle.

Given the small share of durables in aggregate consumption (20%), a high value for the q-elasticity is essential in order for the model to explain the stylized facts. Differenent people will hold different views therefore of the extent to which the results help rehabilitate the weak credibility hypothesis. For our part, we do not consider the sensitivity of the results to Ω a significant limitation. A priori, since durables expenditure is a form of investment (misclassified as consumption in the national income accounts), it should be much more responsive than nondurables consumption to intertemporal price variation (Calvo, 1988; Vegh, 2010). A high value for the q-elasticity is consistent with this and with the raw data showing extreme volatility of durables expenditure in ERBS programs. Both theory and the empirical evidence currently at hand support the presumption that Ω is large.

4. Habit Formation

While the model delivers good results for the magnitude and the composition of the consumption boom, it does less well in accounting for the slope of the consumption path. The time profiles of aggregate consumption and durables spending are essentially the same in each case: a sharp jump at $t = 0$, a succeeding flat stretch for the next 1.5 years, and then rapid, accelerating growth until the end of year three. This is at variance with the

facts. Consumption rose continuously in some ERBS episodes (e.g., Argentina, 1967-1970; Brazil, 1964-1968; Mexico, 1988-1994; Peru, 1985-1987; Paraguay, 1991-1997);[8] in others, a flat stretch or a downturn materialized, but only in the last year of the program.

The results in Uribe (2002) suggest that a model with habit formation might generate a more realistic path for consumption. Following Carroll et al. (2000) and Fuhrer (2000), let the stock of habit H grow at the rate

$$\dot{H} = v(N - H), \tag{22}$$

where $v > 0$ and

$$N \equiv \left(C^{1-1/\tau} + a_o D^{1-1/\tau}\right)^{\tau/(\tau-1)}.$$

Habit enters the utility function with the persistence parameter α. Two formulations dominate the literature:

$$U(N, H) = \frac{(N - \alpha H)^{1-1/\tau}}{1 - 1/\tau}, \quad 0 < \alpha < 1 \tag{23a}$$

and

$$U(N, H) = \frac{(N/H^{\alpha})^{1-1/\tau}}{1 - 1/\tau}, \quad 0 < \alpha < 1. \tag{23b}$$

In the additive specification, utility is a function of the *difference* between current consumption and the stock of habit (also called the "subsistence level of consumption"). The multiplicative specification assumes that felicity depends instead on consumption *relative* to the stock of habit. The difference in emphasis is slight but important. Both specifications capture the basic idea of habit formation — that the private agent desires to smooth the change as well as the level of consumption. The choice of functional form also affects, however, the ease of intertemporal substitution and the degree of complementarity/substitutability between durables and nondurables during periods of adjustment where $H \neq N$.

There is general agreement in the literature that the persistence parameter α is on the order of .70. Unfortunately, no similar consensus exists about the likely value of v. Numerous papers postulate very rapid habit formation, citing Fuhrer (2000) for support. It is common practice, for example, to set the stock of habit equal to last quarter's consumption. At

the opposite extreme, the evidence marshalled in Constantinides (1991), Heaton (1995), and Boldrin et al. (1997) suggests that it takes years for habits to fully adjust. Carroll et al. (2000) and Mansoorian and Michelis (2005) subscribe to this view, calibrating their models with $v = .20$.

In the next two sections we present results for the case where $\tau = .25$, $\Omega = 10$ and $\alpha = .70$. Since our approach is exploratory, we do not take sides in the debate about the right value for v or the right way to put habit in the utility function. Habit may enter the utility function additively or multiplicatively and v takes either the low value .5 or the high value 6.5. In the runs with $v = 6.5$, the stock of habit covers 80% of the distance to its new long-run level within one quarter. For $v = .5$, the 80% point is not reached until 3.25 years elapse.

4.1 The Additive Specification

Habit formation moderates consumption growth most in the early and late stages of ERBS as the private agent tries to smooth the large jumps in C and S at $t = 0$ and $t = T$. This tends to lower the peak level of aggregate consumption during the ERBS phase. Under the additive specification, the consumption boom is also weakened by temporarily lower values for the intertemporal elasticity of substitution. At $t = 0$, the stock of habit is fixed and

$$-\left.\frac{U_N}{U_{NN}N}\right|_{H \text{ constant}} \equiv \bar{\tau} = \tau\left(1 - \alpha\frac{H}{N}\right).$$

But after full adjustment

$$-\left.\frac{U_N}{U_{NN}N}\right|_{dH=dN} = \tau.$$

Because $\bar{\tau} < \tau$, consumption expenditure *always* increases less than in the model without habit formation. How much less depends on v and the amount of time elapsed since the start of the stabilization program. In the case where $v = 6.5$, rapid habit formation brings $\bar{\tau}$ close to τ in the space of six months. For $v = .5$, however, the difference between $\bar{\tau}$ and τ is large in the first half of ERBS and nontrivial at the end of the program.

The relationship between habit formation and the trajectory of nondurables consumption is more complex. As usual, higher consumption today raises the marginal utility of

consumption tomorrow by increasing the stock of habit. If the story ended here, we could be sure that habit formation would impart an upward tilt to the path of nondurables consumption. But it doesn't. There are two complicating factors. First, the desire to smooth the fall in consumption at T tends to ratchet the consumption path southward immediately after the jump at $t = 0$. Second, habit formation changes the relationship between durables consumption and nondurables consumption. Initially durables and nondurables are Edgeworth independent ($U_{CD} = 0$). After the ERBS shock, they are Edgeworth substitutes until habit catches up with consumption. Define $\theta_d \equiv (r+\delta)D/[(r+\delta)D + C]$ to be the share of durables services in aggregate consumption. Then

$$\left.\frac{U_{CD}D}{U_C}\right|_{dH=dN} \equiv \eta = 0,$$

with full adjustment, whereas

$$\left.\frac{U_{CD}D}{U_C}\right|_{H \text{ constant}} \equiv \bar{\eta} = \frac{\theta_d}{\tau}\left(1 - \frac{N}{N - \alpha H}\right)$$

at $t = 0$. In the model without habit formation, $\eta = \bar{\eta} = 0$ and we get the flat paths for nondurables consumption seen in Figure 2. Introducing additive habit formation causes the elasticity to decrease temporarily from zero to a negative number. Moreover, the number may be large. Evaluated at $N = 1.1H$, $\alpha = .70$, and $\theta_d = \tau = .25$, for example, $\bar{\eta}$ is a hefty -2.75. The overall impact on the trajectory of nondurables consumption is thus highly uncertain.

Panel A in Figure 3 is an example where the complicating factors and slow habit formation ($v = .5$) lead to mixed results. In some respects, the transition path looks better. Habit formation cuts the initial jump in S from 40% to 22% and shortens the flat stretch of the consumption path by half a year. But the price for these gains is a three percentage point reduction in peak expenditure growth and a much less realistic path for nondurables consumption, which drops *below* its pre-ERBS level at the end of year two. The underlying source of trouble is that H lags N far into the ERBS period: hence $\bar{\tau} < \tau$ has a significant effect on the peak level of consumption (although an 18.7% increase is still pretty good), while Edgeworth substitutability and prior adjustment to mitigate the anticipated contraction at T cause the post-jump path of C to angel sharply to the southeast.

The obverse conclusion, confirmed in Panel B, is that increasing v to 6.5 should improve the fit with the stylized facts. Rapid habit formation gives rise to a nice hump-shaped path for nondurables consumption just as in Fuhrer (2000) and Uribe (2002); it also pushes the peak increase in aggregate consumption back above 20% and eliminates the embarrassing U-shaped portion of the path. Problems remain, especially with regard to the distribution of expenditure growth across periods, but the adjustments are in the right direction. The time profiles for aggregate consumption and its principal components are uniformly superior to the time profiles in the model without habit formation.

4.2 The Multiplicative Specification

In the additive specification, durables and nondurables are Edgeworth substitutes ($U_{CD} < 0$) and the intertemporal elasticity of substitution is less than τ until habit adjustment is complete. The multiplicative specification has very different implications. In the extreme short run (where H is fixed), the intertemporal elasticity equals τ and the utility function is separable in durables and nondurables consumption ($U_{CD} = 0$). Over time, however, intertemporal substitution becomes easier (Carroll et al., 2000) and accumulation of durables exerts a positive effect on the marginal utility of nondurables consumption. After habits have fully adjusted,

$$-\left.\frac{U_N}{U_{NN}N}\right|_{dH=dN} \equiv \tilde{\tau} = \frac{\tau}{\tau\alpha + 1 - \alpha} > \tau \quad \text{for} \quad \tau < 1$$

and

$$\left.\frac{U_{CD}D}{U_C}\right|_{dH=dN} \equiv \tilde{\eta} = \frac{\theta_d \alpha(1-\tau)}{\tau} > 0 \quad \text{for} \quad \tau < 1.$$

Since $\tilde{\tau} > \tau > \bar{\tau}$ and $\tilde{\eta} > 0 > \bar{\eta}$, the multiplicative specification is sure to deliver bigger booms for nondurables consumption and aggregate consumption than the additive specification. In fact, both booms could be *stronger* than in the model without habit formation. Habit still motivates the agent to undertake prior adjustments to smooth the sharp drop in consumption at the time of the policy collapse. But $\tilde{\tau} > \tau$ strengthens the incentive to substitute from future to current consumption, and both habit growth and accumulation of durables work to increase the marginal utility of nondurables consumption over time

($H \uparrow \rightarrow U_C \uparrow$ *and* $D \uparrow \rightarrow U_C \uparrow$). These effects are potentially significant: in our calibration where $\alpha = .70$ and $\theta_d = .30$, full habit adjustment raises τ from .25 to .53 and $\tilde{\eta}$ from 0 to .63. Again, therefore, much depends on v, the parameter that determines the speed of habit growth. Large values of v increase the likelihood that the aggregate consumption boom will be stronger than in the benchmark model and that the path of nondurables consumption will be higher and upward-sloping for most of the ERBS phase.

Panels C and D in Figure 3 affirm these analytic-based conjectures. Switching to the multiplicative specification affects mainly the height of the consumption paths. The difference is substantial in the run for $v = 6.5$. Absent habit formation, nondurables consumption jumps 3.4% at $t = 0$ and then stays flat for the rest of the ERBS period. In Panel B, by contrast, C surges 6% in the first six months, rising to a peak of 8% at $t = 2.25$. Since durables spending also rises more at the outset, total consumption growth at $t = 1$ and $t = 2$ is 5-6 percentage points higher than in the model without habit formation. The gap narrows in the third year but does not disappear. Thus, when the multiplicative specification combines with rapid habit formation, there is no tradeoff of better slope for lower height — the path of aggregate consumption is *continuously* above the no habit formation path.

4.3 An Interim Progress Report

We pause briefly to make two observations about what has and has not been achieved up to this point. First, regardless of whether one favors the multiplicative or the additive specification, the case for habit formation requires very fast adjustment in the stock of habit. There is not much to choose from between a model with slow or moderately fast habit formation and a model with no habit formation. Second, while the introduction of rapid habit formation produces better results, it is not a complete fix. The paths for durables spending and aggregate consumption still have the wrong shape — growth should be greater in the second year than in the third, not the other way around. This motivates us to investigate a less conventional specification of habit formation.

4.4 Habit Formation in Durables Spending

So far we have followed Bernanke (1985) in assuming that deliberation costs depend on how

fast the stock of durables changes. This is not the only sensible specification. It is equally plausible that the private agent experiences psychological unease when durables spending S varies from its customary level. Suppose therefore

$$R(S,H) = x\frac{(S/H-1)^2}{2}H, \tag{24}$$

where

$$\dot{H} = v(S-H), \quad v > 0. \tag{25}$$

Naturally, we hope that habit formation will now generate a smooth hump-shaped path for S and, by extension, for aggregate consumption. The idea is not new. Appealing to the notion that firms need "time to plan," many New Keynesian and Real Business Cycle models now employ a similar strategy to dampen the volatility of investment (Christiano and Vigfusson, 1999; Edge, 2000; Burnside et al., 2004; Gali and Gertler, 2007).

Panel E in Figure 3 shows the outcome when $\tau = .25$, $\Omega = 5$, $v = 3$, and habit formation appears only in the deliberation cost function. We would like to include habit formation in the utility function as well, but, at present, our computer program cannot solve for the nonlinear saddle path in systems that have more than three jump variables.[9] The new specification is *perforce* less than ideal.

Even so, the run in Panel E gives us almost everything we want. The paths for durables spending and aggregate consumption are hump-shaped, with expenditure contracting rapidly in the last six months of the program. Equally important, the pace of consumption growth does not slow until the start of the third year. Durables spending increases 46% in year one, 42% in year two, and 11% in the first half of year three. The corresponding numbers for aggregate consumption are 12%, 12% and 5%. Perhaps the most surprising result is that the peak increases in durables spending and aggregate consumption are 2-2.5 times as large as in the model without habit formation. This is a natural consequence, however, of substituting H for D in the deliberation cost function. Increases in H reduce marginal deliberation costs in (24) in the same way that increases in D do when $R = x(S/D-\delta)^2 D$. But habit formation is extremely fast relative to durables formation (v is large and H is only a tenth the size of D). Hence, after about six months, the higher level of S becomes

routine and marginal deliberation costs decrease sharply. This paves the way for a boom that is both smoother and much more powerful than in the model without habit formation.

Sensitivity Analysis

The numerical simulations in Panel E of Figure 3 assume that all durables spending enters the scale variable in the liquidity cost function. If some durables are pure credit goods, this exaggerates the incentive to shift purchases from the future to the present when the reduction in the crawl is temporary. Our own view is that most durables spending belongs in the liquidity cost function.[10] Given the paucity of empirical evidence, however, the right specification of the scale variable is a judgment call.

We have undertaken additional runs to test the sensitivity of the results to the coefficient on S in the liquidity cost function. In the modified runs, we write the scale variable as $C + \xi S$ and reduce ξ from unity to .50 or .25.

The results hold up surprisingly well. Because smaller values of ξ lessen the impact of S on liquidity costs, the percentage decrease in durables spending is much smaller than the decrease in ξ. The peak increase in aggregate consumption drops from 29% when $\xi = 1$ to 22% when $\xi = .50$ and to 18% when $\xi = .25$. These are nontrivial decreases, but 18% and 22% are still big numbers. Clearly, ξ close to unity is not essential to a durables-driven explanation of the consumption boom.

5. Adding a Nontradables Sector and Supply Effects

In this section we add a nontradables sector, a labor-leisure choice, and sector-specific capital to the model. These additions allow us to demonstrate that the powerful consumption boom is not an artifact of the one-good model, that the weak credibility hypothesis can account for strong, sustained appreciation of the real exchange rate, and that supply effects are helpful but not essential to a full explanation of the ERBS syndrome.

The traded good, now called the export good, serves as the numeraire in the model. Thus, unless otherwise indicated, prices and monetary aggregates are divided by the nominal exchange rate. Other notational conventions are as follows: P_n, w, Q_i, L_i, K_i, and C_i refer to the price of the nontraded good, the wage, production, employment and capital in sector i (i = n,x), and nondurables consumption of good i.

Technology and Labor Demand

Competitive firms operate CES production functions

$$Q_x = F(K_x, L_x) = [a_3 L_x^{(\epsilon-1)/\epsilon} + a_4 K_x^{(\epsilon-1)/\epsilon}]^{\epsilon/(\epsilon-1)}, \tag{26a}$$

$$Q_n = G(K_n, L_n) = [a_5 L_n^{(\epsilon-1)/\epsilon} + a_6 K_n^{(\epsilon-1)/\epsilon}]^{\epsilon/(\epsilon-1)}, \tag{26b}$$

and hire labor up to the point where its marginal value product equals the wage:

$$F_L = w, \tag{27}$$

$$P_n G_L = w. \tag{28}$$

Equations (27) and (28) assume labor is intersectorally mobile even in the short run. This strong assumption will be relaxed later in Section 6.3.

Consumption of multiple durable goods greatly complicates the model. To avoid this, we assume that one unit of the imported durable always combines with a_7 units of the nontraded durable. The price of the composite durable is thus

$$P_d = 1 + a_7 P_n. \tag{29}$$

Similarly, factories are built by adding a_8 units of a nontraded input (construction) to one imported machine:

$$P_k = 1 + a_8 P_n. \tag{30}$$

The Private Agent's Optimization Problem

The private agent solves his optimization problem in two stages. In the first stage, C_n and C_x are chosen to maximize $C(C_n, C_x)$, subject to $P_n C_n + C_x = E$, where E is total nondurables expenditure and $C(C_n, C_x)$ is a linearly homogenous CES aggregator function. The optimal choices $\bar{C}_n$ and $\bar{C}_x$ are subsumed in the indirect utility function

$$V(P_n, E) = C[\bar{C}_n(P_n, E), \bar{C}_x(P_n, E)] = E/c(P_n),$$

where

$$c(P_n) = \left(k_o^\beta + k_1^\beta P_n^{1-\beta}\right)^{1/(1-\beta)},$$

k_o and k_1 are distribution parameters, and β is the elasticity of substitution between the two consumer goods.

Labor supply L_s, sectoral investment I_j $(j = n, x)$, and either export or nontradables sector employment are new control variables. In the second stage of optimization, the agent chooses these variables along with m, b, E, and S to maximize

$$U = \int_0^\infty \left[\frac{(N/H_1^\alpha)^{1-1/\tau}}{1-1/\tau} - a_9 L_s^\phi - x\frac{(S/H_2-1)^2}{2} H_2 \right] e^{-\rho t} dt, \tag{31}$$

subject to

$$\begin{aligned}
A &= m + b, && (32)\\
\dot{A} &= P_n G(K_n, L_n) + F(K_x, L_s - L_n) + \tilde{g} + rb - (E + P_d S)\left[1 + L\left(\frac{m}{E + P_d S}\right)\right] \\
&\quad - P_k\left[I_n + f\frac{(I_n/K_n - c)^2}{2}K_n\right] - P_k\left[I_x + f\frac{(I_x/K_x - c)^2}{2}K_x\right] - \chi m, && (33)\\
\dot{D} &= S - \delta D, && (34)\\
\dot{H}_1 &= v(N - H_1), && (35)\\
\dot{H}_2 &= v(S - H_2), && (36)\\
\dot{K}_n &= I_n - cK_n, && (37)\\
\dot{K}_x &= I_x - cK_x, && (38)
\end{aligned}$$

where

$$N \equiv \{a_1[E/c(P_n)]^{(\sigma-1)/\sigma} + a_2 D^{(\sigma-1)/\sigma}\}^{\sigma/(\sigma-1)};$$

$1/(\phi - 1) > 0$ is the Frisch elasticity of labor supply; c is the capital depreciation rate; σ is the elasticity of substitution between durable and nondurable consumer goods; χ is the rate of crawl of the exchange rate; and the terms $f(I_j/K_j - c)^2 K_j/2$ in (33) capture adjustment costs incurred in changing the capital stock. The specification of preferences is more general than before as we no longer impose $\sigma = \tau$ in the aggregator function $N(\cdot)$.[11] Note also that habit formation operates in both the goods utility function and the deliberation costs function.

The long version of the paper contains the first-order conditions and co-state equations

associated with the solution to the above optimization problem. We omit these here, save

$$a_9 \phi L_s^{\phi-1} = \frac{N_E}{1+L-L'm/X}\left[\left(\frac{N}{H_1^{\alpha}}\right)^{-1/\tau} H_1^{-\alpha} + \omega_3 v\right] F_L, \tag{39}$$

$$-L' = r + \chi, \tag{40}$$

where $X \equiv E + P_d S$ and ω_3 is the multiplier attached to (35). Equations (39) and (40) are the first-order conditions for L_s and b.[12] As will become apparent shortly, they play a pivotal role in determining the aggregate supply response to ERBS.

Net Foreign Asset Accumulation and the Current Account Balance

Summing the budget constraints of the private agent and the government now yields

$$\dot{Z} = P_n Q_n + Q_x + rZ - E - P_d S - P_k \left[I_n + I_x + f\frac{(I_n/K_n - c)^2 K_n}{2} + f\frac{(I_x/K_x - c)^2 K_x}{2}\right]. \tag{41}$$

Market-Clearing Conditions

The model is closed by the conditions that demand equal supply in the labor and nontradables markets. These require

$$L_x + L_n = L_s \tag{42}$$

and

$$\underbrace{E\frac{k_1 P_n^{-\beta}}{k_o^{\beta} + k_1^{\beta} P_n^{1-\beta}}}_{C_n} + a_7 S + a_8 \left[I_n + I_x + f\frac{(I_n/K_n - c)^2}{2}K_n + f\frac{(I_x/K_x - c)^2}{2}K_x\right] = Q_n, \tag{43}$$

where demand for nontraded consumer goods C_n has been retrieved from the indirect utility function via Roy's Identity.

Solution Technique

The core dynamic system in the model has six jump variables [E, S, I_x, I_n and the multipliers paired with (35) and (36)] and six state variables (D, Z, K_x, K_n, H_1, and H_2). Our algorithms cannot solve these higher-order systems for the global nonlinear saddle path. Consequently, the zero eigenvalue/unit root reappears as an insoluble problem.

To circumvent this difficulty, we adopt Schmitt-Grohe and Uribe's (2003) suggestion to

let the real interest rate depend very weakly on the country's debt-GDP ratio:

$$r = \rho + \kappa \left(\frac{b}{P_n Q_n + Q_x} - \frac{b_o}{P_{n,o} Q_{n,o} + Q_{x,o}} \right), \quad \kappa < 0. \tag{44}$$

κ is assigned a small value to close to zero (.0001 in the simulations) so that the loan supply curve is almost perfectly flat. This converts the zero eigenvalue in the perfect capital markets model into a tiny negative eigenvalue in the approximating model.

5.1 Key Features of the Model

Before presenting the latest results, we draw attention to two important features of the model. First, all *positive* supply effects derive, directly or indirectly, from the first-order condition for the optimal supply of labor. It is evident from inspection of (39) and (40) that a lower rate of crawl raises the return to work by reducing the nominal interest rate and the effective price of consumption. The jump in employment, in turn, increases the marginal product of capital ($F_{KL}, G_{KL} > 0$), spurring firms to invest more, *ceteris paribus* (an important qualification in the case of temporary ERBS — see Section 6.2). Across steady states, output, employment, and the capital stock in each sector increase by the same percentage amount as the supply of labor. The real exchange rate appreciates in the short and medium run, but returns to its original level in the long run.[13]

The other noteworthy feature of the model is that firms accumulate capital in both sectors. By contrast, the rest of the ERBS literature restricts investment to the tradables sector. This bothers us. Symmetry is not only more natural, it is also important to the credibility of the results. Keeping capital out of the nontradables sector puts a thumb on the scale, creating a bias toward the desired outcome of strong appreciation of the real exchange rate. The story line is simple. On impact, P_n jumps upward as higher investment in the tradables sector increases demand for nontraded capital inputs.[14] Beyond the short run, expansion in the tradables sector raises real income and either decreases or slows employment growth in the nontradables sector. Higher real income pushes the demand curve in the nontradables sector further to the right, while the transfer of labor to the tradables sector shifts the supply curve to the left. Both factors pull in the direction of more appreciation of the real exchange rate.

Under symmetry, things play out very differently. Since the terms of trade move in favor

of the nontradables sector, the supply boom is concentrated there. Thus the *pure* supply effects serve to moderate appreciation of the real exchange rate. In fact, at the end of the day, they prevent any change in P_n. This does not imply, however, that real appreciation is continuously less than in the model without supply effects. Supply-side expansion takes time to develop, whereas the impact of higher wealth on durables spending is immediate and large. For a while, demand grows more rapidly (ex ante) than supply in the nontradables sector.

6. Calibration of the Model and Numerical Solutions

> "At a *quantitative* level the results for our baseline parameterization fall short of explaining the orders of magnitude involved in stabilization episodes, suggesting that the large consumption booms and the sizable real appreciations are puzzling." (Rebelo and Vegh, 1995, p.168)

Table 1 lists the parameter values used to calibrate the expanded model. None of the values are terribly exotic. Durables are more import intensive than nondurables, habit formation is rapid ($v = 6.5$), and ordinary numbers are assigned to the cost share of labor, the elasticity of substitution between traded and nontraded nondurables, the cost share of nontradables in the production of investment goods, and the elasticity of substitution between capital and labor (all equal .50). The ratio of money balances to consumption is .15 vs. .10 in the one-sector model.[15] The higher value is in line with the ratio of M1 to consumption for many ERBS episodes in Latin America. It is too low, however, for most episodes in Africa.[16] On the supply side, we set ϕ so that labor supply increases 5.5-6.5% when ERBS is permanent and f so that the elasticity of investment with respect to Tobin's q equals .25, 1 or 2. The response of labor supply is in line with response assumed in Rebelo and Vegh (1995) and with the responses reported in Roldos (1995) for Mexico's 1987 Solidarity Pact and Argentina's 1991 Convertibility Plan, while the alternative values for the q-elasticity correspond to low, middle and high-end estimates in the literature on empirical investment functions.[17]

6.1 No Supply Effects

We first investigate a variant of the model that holds aggregate labor supply, sectoral in-

vestment, and the sectoral capital stocks constant. This is an application of Occam's razor: before complicating the model with multiple supply effects, we should ascertain the extent to which demand effects alone can explain the stylized facts.

Figure 4a shows the paths of aggregate consumption, durables spending, and the relative price of the nontraded good in the base run where $\tau = .25$ and $\sigma = .75$. The peak increases in these variables for all runs are collected in Table 2. This is done to save space and facilitate comparisons across models and parameter values. The graphs always have the same general shape; what differs is the scale on the vertical axis.

Despite its simplicity, the no-frills flexprice model performs quite well. Aggregate consumption increases 17-22% at the same time that the real exchange rate appreciates 24-26%. As usual, the consumption boom is driven by a tremendous surge in durables spending. Observe also that adjustment is difficult in the post-ERBS period. In the first year after the policy reversal, the slump deepens and the real exchange rate depreciates continuously. This is followed by slow recovery to the pre-ERBS equilibrium. Even at year five, aggregate consumption and the real exchange rate are 8-10% below their initial levels.

6.2 Supply Effects

> " . . . further work on the structure of the supply-side and on the differential response of the tradable and non-tradable goods sector — which would allow us to build more refined quantitative models — would be particularly useful." (Calvo and Vegh, 1999, p.1581)

Figure 4b and Panel B of Table 2 contain the results for the full-bodied model that incorporates variable labor supply and private sector capital accumulation. The fit with the stylized facts is excellent, including the temporal and sectoral distribution of supply effects. Investment decreases slightly in both sectors, while employment and output rise sharply in the nontradables sector and fall in the export sector. Real GDP is 2.5-3% higher at the peak of the boom, and recessionary pressures appear 6-9 months before ERBS collapses. On the demand side, although the supply response is temporary and the associated wealth effect small, the consumption boom is *significantly* stronger than before. The peak increases in durables spending and aggregate consumption are 79-142% and 23-35%; without supply effects, the ranges are 57-97% and 17-22%. Finally, despite rapid supply expansion in the

nontradables sector, ERBS is still compatible with pronounced appreciation of the real exchange rate: because the consumption boom is so strong, P_n increases 17-25%.

Simple demand vs. supply and relative price effects explain strong appreciation of the real exchange rate and the impact on sectoral output and employment. It is not obvious, however, what lies behind the new, bigger numbers for the consumption boom. As noted, the peak levels of durables spending and aggregate consumption increase 22-45 and 7-12 percentage points, respectively, even though real income rises only 2.5-3% during the ERBS phase. The juxtaposition is surprising: why should a relatively small supply-based wealth effect add so much to the consumption boom? The additional gains are actually several times larger than the peak values for durables spending and aggregate consumption in the case where ERBS is credible and real income rises permanently by 5.5% (see Section 7).

On reflection, none of this is paradoxical. The increases in labor supply and real income do not last beyond the ERBS phase. The agent wishes therefore to save most of the temporary income gain. A large part of the saving (really less dissaving) is channeled into additional purchases of durables: by making heavy outlays to accumulate durables in the ERBS phase, the private agent ensures that stock of durables and the flow of consumption services will be higher than otherwise in the post-ERBS period. This *saving-through-durables* effect explains why aggregate consumption expenditure increases much more than in the model with no supply effects; via the stronger consumption boom, it also explains why the real exchange rate appreciates 17-25% despite a 14% increase in nontradables sector employment.

A. **The Path of Private Investment**

The stylized facts for private investment are not nearly as well defined as those for consumption, capital flows, and the real exchange rate. Nevertheless, a judgment of the model requires a judgment about whether the solution path for private investment is reasonable. Below we comment on (i) the interdependence of the consumption and investment dynamics and (ii) how the results for investment compare to the empirical evidence.

- Since the increase in labor supply raises the marginal product of capital, it might seem odd that investment falls. The decrease in the nominal interest rate, however, lowers the effective price of consumption relative to the price of capital. This creates an incentive to substitute away from fixed investment toward current consumption during the ERBS phase. Substitution between the two assets is easier and the consumption boom stronger

when the q-elasticity of investment equals two (see Table 2). Total spending increases less, however, making it more difficult to explain strong appreciation of the real exchange rate.

- At the trough of the cycle, investment is lower by 15-20% in the runs where the q-elasticity equals two and by 2-4% in the runs where the q-elasticity equals .25. Neither result contradicts the stylized facts. The raw numbers for fixed investment are all over the map in ERBS programs (Kiguel and Liviatan,1992; Reinhart and Vegh, 1995b; Calvo and Vegh, 1999), and the estimated impact is weak and statistically insignificant in Hamaan's (2001) large panel dataset.
- The stabilization time profile for fixed investment in Calvo and Vegh (1999) shows an initial decline of 7-10% followed by recovery to a temporarily higher level in the post-ERBS period. Our model generates the same investment cycle, with similar numbers, when the q-elasticity of investment spending equals unity (see Figure 11).
- The model suggests two explanations for the mix of positive and negative outcomes in the data.[18] First, as will be seen in Section 6.3, investment increases sharply when ERBS is permanent (or perceived as credible). Thus variations in the response of investment might reflect variations in the credibility of different ERBS programs. Second, it can be argued that part of investment spending should enter the scale variable in the liquidity cost function. This would introduce another pro-investment effect (alongside higher labor supply) that competes against the substitution-toward-durables effect. We conjecture that the sign and the magnitude of the impact on investment in non-credible programs would then be sensitive to small variations in the coefficient on I in the liquidity cost function.

B. **An Important Refinement**

Twenty-five percent appreciation of the real exchange rate is very good by the standards of the literature, but not good enough. While there is always a problem in controlling for other effects, it appears that in some episodes ERBS caused the real exchange rate to appreciate 40-50% (Calvo and Vegh, 1994b, Table 1).

A refinement of the model helps a great deal here. Suppose firms incur adjustment costs when changing the workforce. This converts L_n and L_x into state variables, producing a smoother, more realistic supply response (there is no jump in nontradables output at $t = 0$).

In Panel C of Table 2 we assume adjustment costs are the same for labor and capital. Overall, the results now match up better with the data. The consumption boom is no less powerful than in the model without supply effects, but appreciation of the real exchange rate rises to 26-38%.

7. Permanent ERBS

> "It should be pointed out, however, that for the purposes of our model the wealth effect need not be necessarily large since there is a 'multiplicative' effect brought about by the bunching in the purchase of durable goods. Hence, it is conceivable that a relatively small wealth effect may have a large impact on durable goods purchases." (De Gregorio et al., 1998, pp.126-127)

The stylized facts for successful ERBS programs look much like those for failed programs.[19] This a problem for the models that ignore supply effects. When ERBS is credible, the relative price of current consumption does not decrease and the private sector does not shift spending from the future to the present. Consequently, adjustment is instantaneous. There are no transitory changes in consumption, the real exchange rate, or the current account deficit. The economy jumps immediately to the new low-inflation steady state.

In the case of a credible program, wealth effects have to propel the consumption boom. Most of the literature has focused on models where increases in wealth stem from supply-side expansion. As noted in the introduction, these models have not been successful in explaining the stylized facts. But this might change in more elaborate models that distinguish between nondurable and durables consumption. Durables spending responds strongly to wealth shocks. Even a modest increase in wealth has the potential therefore to trigger a multi-year consumption boom. The sticking point is that the normal definition of boom does not apply. When the context is ERBS, we need *really* big numbers.

The bottom line in Figure 5 and Table 2 is easy to discern: credibility makes supply-based wealth effects stronger, but, without intertemporal substitution, the paths for aggregate consumption, durables spending, and the real exchange rate peak much too early and far too low. This conclusion is extremely robust. Fishing for better numbers, we experimented with alternative values for every parameter in the model. The results always came back looking like Figure 5. Our search did not turn up a single case in which the peak increases for both aggregate consumption and the real exchange rate exceeded 10%.

These results cast doubt on the thesis of De Gregorio et al. (1998) that the wealth effects associated with credible ERBS can account for the boom phase of the consumption cycle via their impact on durables spending. Our model of durables expenditure postulates deliberation costs instead of an S-s rule, but this difference is superficial. We get the bunching

pattern predicted by their analytical results: the surge in durables expenditure is packed into the first six months of the transition path. The numerical simulation also incorporates a *large* wealth effect — the increase in real income from supply-side expansion is 5.5%. Nevertheless, the consumption boom lacks height and length. The thesis in De Gregorio et al. isn't exactly wrong. After all, a consumption boom of 5% is pretty good. But, to repeat, ERBS is special: the stylized facts demand much bigger numbers.

8. Concluding Remarks

Many supporters of the weak credibility hypothesis probably sympathize with the theorist who complained that "facts are inconvenient things." In empirical tests, models reliant on the hypothesis have not come close to explaining the dramatic consumption boom seen in ERBS programs. But maybe the problem is with the models as opposed to the hypothesis. The tests were conducted on models that assume all consumption is nondurable. Since the response of nondurables consumption is limited by the low value of the intertemporal elasticity of substitution, it was almost a foregone conclusion that the models would fare poorly when confronted with the data.

In this paper we have used a mix of theory and numerical methods to investigate the explanatory power of the weak credibility hypothesis in more general models that allow for both durable and nondurable consumer goods. Inclusion of durables is essential for a fair test. Because refrigerators, TVs, etc. provide a service flow for many years, large-scale purchases of durables do not unbalance the consumption path in the same way as a spike in nondurables expenditure. Consequently, low values of the intertemporal elasticity of substitution do not preclude a durables-driven consumption boom. Our results go further and argue that the weak credibility hypothesis is a very promising hypothesis. In numerical simulations based on conservative assumptions about the expenditure share of durables (20%) and wealth effects (none), aggregate consumption increases 17-22% and the real exchange rate appreciates 24-26% during the low-crawl phase. In every case, the boom is powered by spectacular, eye-catching growth in durables spending; when durables are removed from the model, the peak increase in consumption is only 4-8%.

The model with a standard time-separable utility function suffers from the shortcoming

that the path to the peak of the consumption boom has the wrong shape. Consumption grows too fast at the beginning and the end of ERBS and too slow in the middle. This can be fixed by adding habit formation to the model, but only if habit affects deliberation costs involved in purchasing durable goods. For conventional specifications of habit formation, the trajectory of nondurables consumption is hump-shaped but the improvement in the paths of durables spending and aggregate consumption is comparatively modest. Shifting habit formation from the utility function to the deliberation cost function solves the latter problem by strengthening the incentive to smooth the path of durables spending. In the runs with this specification, the paths of durables expenditure and aggregate consumption are steeply sloped and hump-shaped: spending rises apace for two years, then slows and contracts sharply in the last year.

In their influential survey paper, Rebelo and Vegh (1995) assert that supply-side effects are "an essential component in accounting for the stylized facts of exchange-rate-based stabilizations." We disagree. A pedestrian flexprice model that appeals to weak credibility does an excellent job of explaining the stylized facts provided durables are part of the consumption basket and habit formation is modeled in the right way. But supply effects are helpful if not essential. Variants of the model that allow for endogenous labor supply and sector-specific capital accumulation add another 7-12 percentage points to the consumption boom or another 4-12 percentage points to appreciation of the real exchange rate. Fully armed, the weak credibility hypothesis can account for ERBS episodes where aggregate consumption rose 35% (e.g., Argentina, 1991-1994) and the real exchange rate appreciated 40%.

Supply and wealth effects operate at maximum strength when ERBS is perceived to be credible. Even in a model with durables, however, they are not potent enough to explain the quantitative aspects of the ERBS syndrome. In our model, increases in labor supply and the capital stock buy, at most, a 5% consumption boom and 3-8% appreciation of the real exchange rate. Something else besides standard supply effects must be fueling a large part of the consumption boom in successful ERBS programs. Finding this last piece of the puzzle is the main priority for future research.

NOTES

1. When the rate of crawl decreases from 100% to 10% for three years, the world market interest rate equals 8%, and the ratio of of real money balances to consumption is 10%, the solution for the peak increase in consumption (C_p) is $(C_p - C_o)/C_o = .064\tau$, where τ is the intertemporal elasticity of substitution. For $\tau = .20$ - .50, the peak increase in consumption is only 1-3%. (The solution stated above is obtained by solving the Calvo-Vegh model for small changes. It is approximately correct for large changes.)

2. On page 562, Uribe observes that "existing models produce consumption booms and real exchange rate appreciations that are too small compared to the actual data," and then acknowledges that "The quantitative analysis conducted in Section 6 . . . does not help resolve this problem."

3. This description of fiscal policy is included only to motivate the failure of ERBS. None of our results depend on the assumption that fiscal policy is completely passive during the ERBS phase. The solutions for the paths of consumption and the net foreign debt are independent of the path postulated for g.

4. x is the change in marginal deliberation costs measured in utils. Dividing by $U_c = C^{-1/\tau}$ expresses the change in marginal deliberation costs in units of nondurables consumption, the numeraire in the model.

5. S and C decrease proportionately in the long run. This and overshooting imply that the contraction in durables spending is greater than the contraction in nondurables expenditure throughout the post-ERBS adjustment process $[(S(t) - S_o)/S_o < (C_2 - C_o)/C_o,\ t > T]$.

6. We ignore Arrau et al.'s estimate for Brazil (3.26 is implausibly high) and use the average of Arrau et al. and Reinhart and Veghs' estimates for Argentina and Chile (.27 and .30, respectively). The simple average of the estimated interest elasticities for Chile, Argentina, Mexico, Brazil and Uruguay then works out to .51.

7. The numbers cited here are for failed, noncredible ERBS programs. The 95% confidence interval in the full sample is 14.1-44%.

8. See DeGregorio, Guidotti and Vegh (1998, Table 1) and Calvo and Vegh (1994b) for data on the episodes in Mexico, Argentina and Brazil. For data on consumption growth in the Paraguayan and Peruvian programs, see *Economic Survey of Latin America and the Caribbean.*

9. In the model without habit formation, the dynamic system has two jump variables, ω_1 and ω_2 (or C and S), the multipliers associated with the constraints in equations (4) and (5). (Even though $\dot{\omega}_1 = 0$, the computer has to solve for the initial jump in ω_1.) When habit formation enters both the utility function and the deliberation cost function, the multipliers associated with the equations governing habit accumulation become part of the dynamic system. This adds two more jump variables to the system.

10. A broad definition of durables includes semi-durables like clothing and footwear. The inclusion of semi-durables and the likelihood that the poorest half of the population pays for most of its durables purchases with cash (even those who are better off may have to make a downpayment to get acceptable credit terms) argues that ξ is closer to unity than zero. It should also be noted that money may facilitate durables purchases through other changes similar in spirit to the liquidity cost function. De Gregorio et al. (1998) emphasize that the purchase of durable goods is time intensive; if money reduces time spent in transactions related to nondurables consumption, it increases the supply of true leisure time and lowers the total time + money cost of buying a durable good.

11. The assumption of a separable utility function did not significantly affect any results in the models of Sections 2-4. We relax the separability assumption now because some of the results in the expanded model are moderately sensitive to the degree of substitutability between durables and nondurables (see Table 2 in Section 6).

12. The original first-order condition reads $a_9 \phi L_s^{\phi-1} = \omega_1 F_L$, where ω_1 is the multiplier paired with with budget constraint (33). Equation (39) emerges after substituting for ω_1 from the first-order condition for E.

13. Across steady states, $P_n G_K(K_n/L_n) = (\rho + c)P_k(P_n)$, $F_K(K_x/L_x) = (\rho + c)P_k(P_n)$, and $P_n G_L(K_n/L_n) = F_L(K_x/L_x)$. These three equations can be solved for K_n/L_n, K_x/L_x, and P_n. None of the variables change in the long run. Under constant returns to scale, they depend only on technology and the rate of time preference.

14. Typically investment is included in the cash-in-advance constraint or the liquidity cost function. This virtually guarantees that investment will increase after the rate of crawl declines.

15. Recall that we chose the low value .10 in the one-sector model to offset any bias toward a strong consumption boom caused by the absence of a nontradables sector.

16. Prior to the adoption of ERBS programs in Chile (1978), Uruguay (1978), Argentina (1978), Ecuador (1993), Brazil (1994), and Venezuela (1990, 1997), the ratio of M1 to private consumption ranged from 12% to 17%. At the start of ERBS episodes in Sierre Leone (1988), Zambia (1990), Egypt (1991), Zimbabwe (1993), Nigeria (1990, 1995), and Mozambique (1996), the range was 13% to 23%.

17. See Buffie (2010) for a review of the estimates for developed countries. There are no reliable estimates for LDCs.

18. Although the empirical evidence is highly mixed, there are well documented cases where ERBS was accompanied by a surge in private investment (e.g., Israel 1985, Mexico 1988, Argentina 1999, and Turkey 2000).

19. There are not many successful ERBS programs. Informed observers contend, however, that many programs enjoyed a high degree of credibility until shortly before they collapsed. See, for example, Dornbusch and Werner (1994), Nazmi (1997), Blejer and Castillo (1998), and Cinquetti (2000).

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Table 1: Calibration of the model with a nontradables sector

	Value
Intertemporal elasticity of substitution	.25, .50
Elasticity of substitution between durables and nondurables	.25, .75
Elasticity of substitution between traded and nontraded nondurables	.50
Share of nontradables in nondurables consumption	.70
Share of nontradables in durables consumption	.30
Share of durables in total consumption spending	.20
Cost share of labor (same in both sectors)	.50
Elasticity of substitution in the CES production functions (same in both sectors)	.50
Speed-of-habit-formation parameter (ν)	6.5
q-elasticity of durables spending	5
Habit persistence parameter	.70
Length of ERBS program	3 years
Slope of the loan supply schedule (κ)	.0001

Table 2: Peak increases in durables spending, aggregate consumption, and the real exchange rate in different variants of the model with a nontradables sector.[1]

	Panel A: Temporary ERBS with No Supply Effects								
	Base Run			$\sigma = .25$			$\tau = .50$		
	DS	TC	RER	DS	TC	RER	DS	TC	RER
	93.0	20.8	23.9	56.7	16.5	23.9	96.8	22.3	26.4
	Panel B: Temporary ERBS with Supply Effects								
	Base Run			$\sigma = .25$			$\tau = .50$		
	DS	TC	RER	DS	TC	RER	DS	TC	RER
$\psi = .25$	120.3	29.1	21.8	79.0	23.2	20.2	127.9	31.8	24.8
$\psi = 1$	127.3	30.5	20.7	83.2	24.2	18.9	134.9	33.4	23.7
$\psi = 2$	134.8	32.1	19.3	87.8	25.1	17.3	142.3	35.1	22.2
	Panel C: Temporary ERBS with Supply Effects and Adjustment Costs to Changing Employment								
	Base Run			$\sigma = .25$			$\tau = .50$		
	DS	TC	RER	DS	TC	RER	DS	TC	RER
$\psi = .25$	86.8	22.7	35.0	52.7	18.6	35.0	93.6	24.5	37.9
$\psi = 1$	99.9	25.4	31.5	62.8	20.6	30.3	106.5	27.6	34.2
$\psi = 2$	113.2	28.1	28.0	72.1	22.5	26.2	119.5	30.5	30.8
	Panel D: Permanent ERBS with Supply Effects[2]								
	Base Run			$\sigma = .25$			$\tau = .50$		
	DS	TC	RER	DS	TC	RER	DS	TC	RER
$\psi = 1$	13.7	5.3	2.9	16.6	5.5	2.8	14.4	5.4	2.7
$\psi = 2$	13.3	5.3	3.5	16.0	5.5	3.4	13.7	5.2	3.3
$\psi = 10$	12.0	5.1	4.4	14.8	5.3	4.3			
	Panel E: Permanent ERBS with Supply Effects and Adjustment Costs to Changing Employment[2]								
	Base Run			$\sigma = .25$			$\tau = .50$		
	DS	TC	RER	DS	TC	RER	DS	TC	RER
$\psi = 1$	6.8	3.6	7.7	7.7	3.6	7.7	7.2	3.7	7.0
$\psi = 2$	7.6	3.9	7.9	8.7	3.9	8.0	8.1	4.0	7.6
$\psi = 10$	9.3	4.4	7.1	11.4	4.6	7.0	9.4	4.4	7.2

[1] Percentage increases relative to pre-ERBS steady state. In all panels, $\tau = .25$ and $\sigma = .75$ in the Base Run. Notation: ψ is the elasticity of investment with respect to Tobin's q; DS is durables spending; TC is total consumption; and RER is the real exchange rate.

[2] Figures for total consumption are the peak increase in the first five years. In the long run, total consumption increases by the same amount as real output (5.5% when $\tau = .25$ and 6.5% when $\tau = .50$).

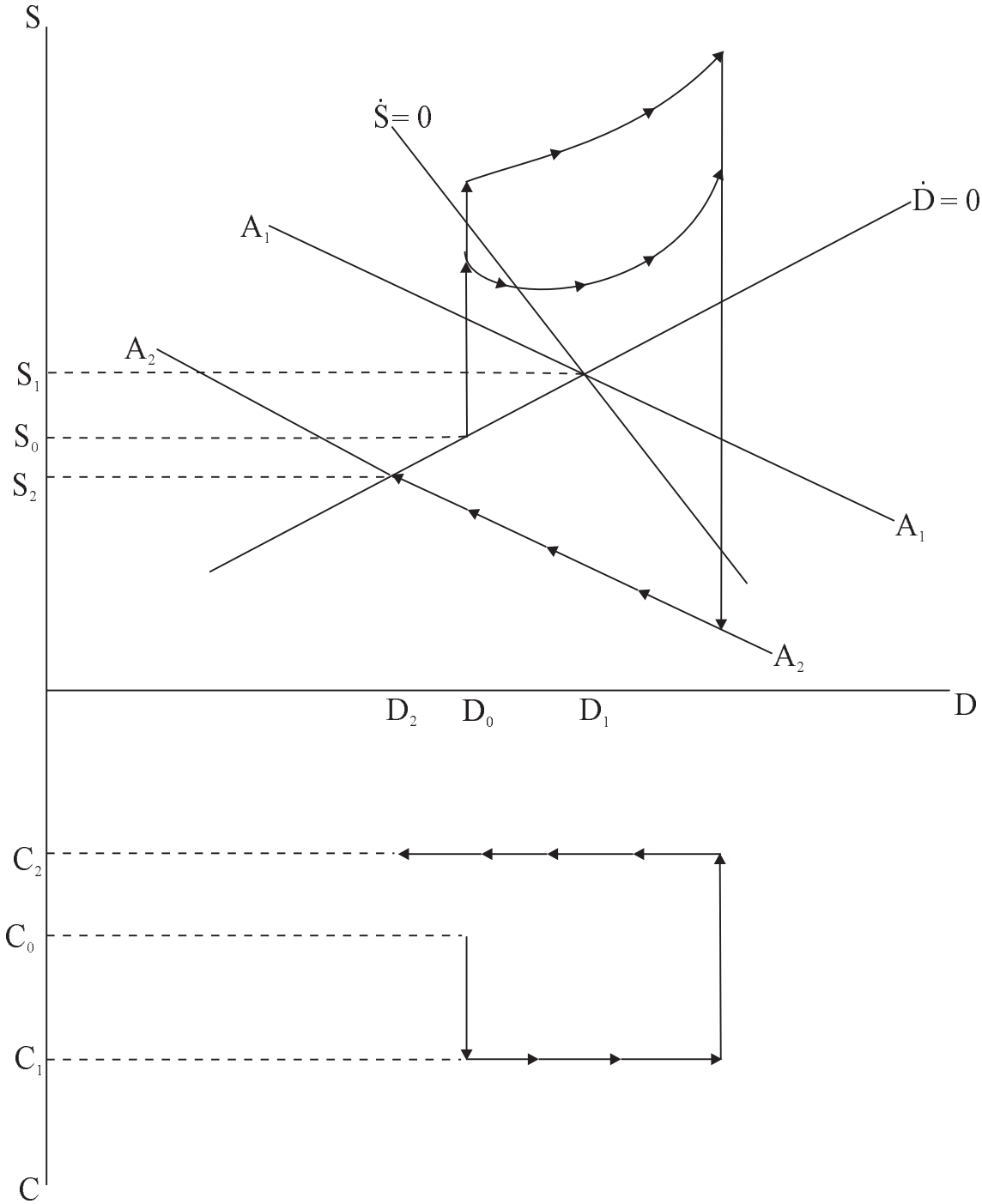
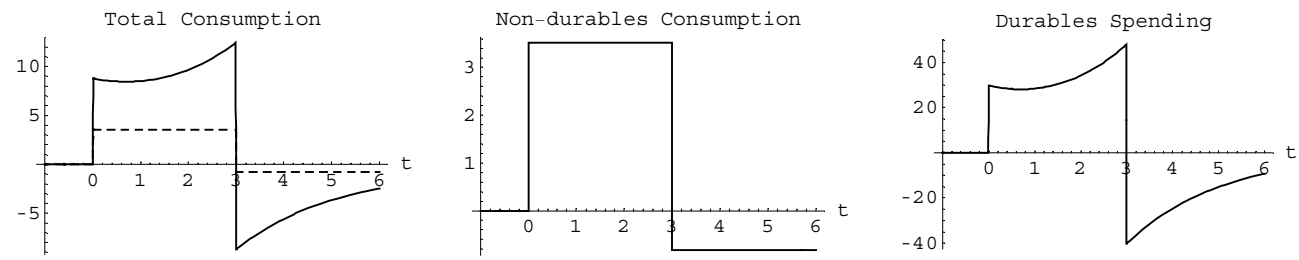
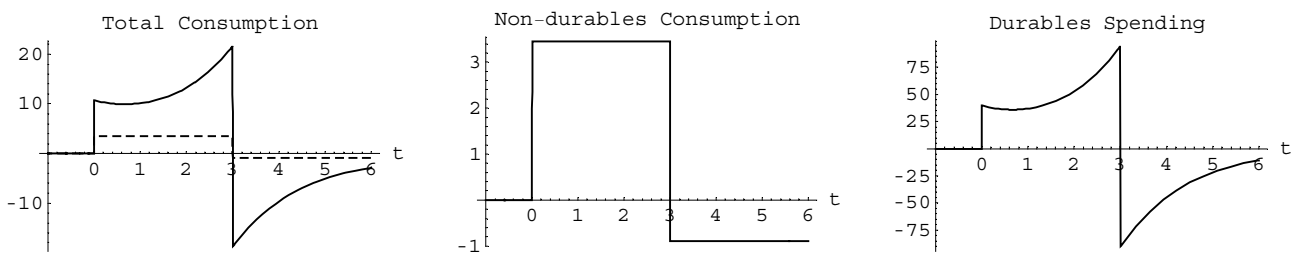


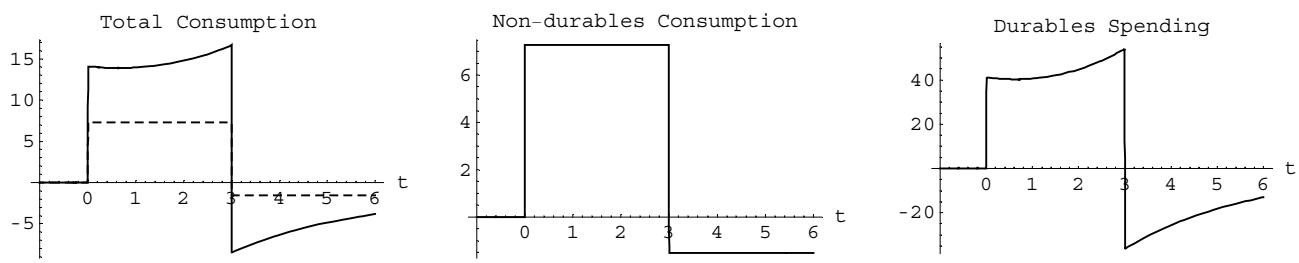
Figure 1: The transition path in the benchmark case of a separable utility function.



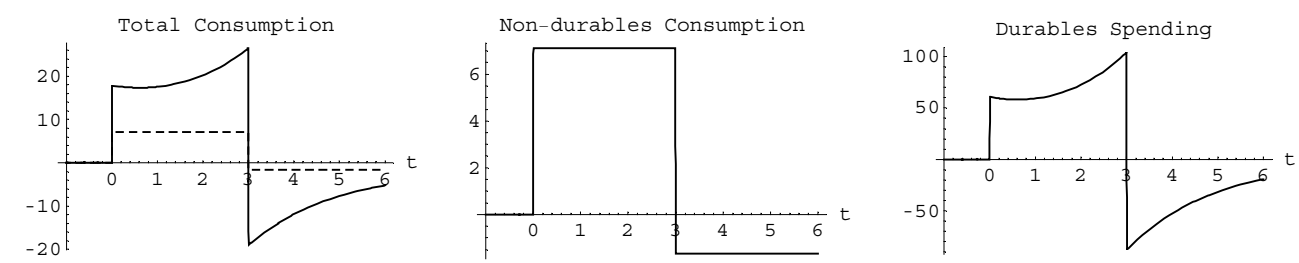
Panel A: τ = .25 and Ω = 5.



Panel B: τ = .25 and Ω = 10.

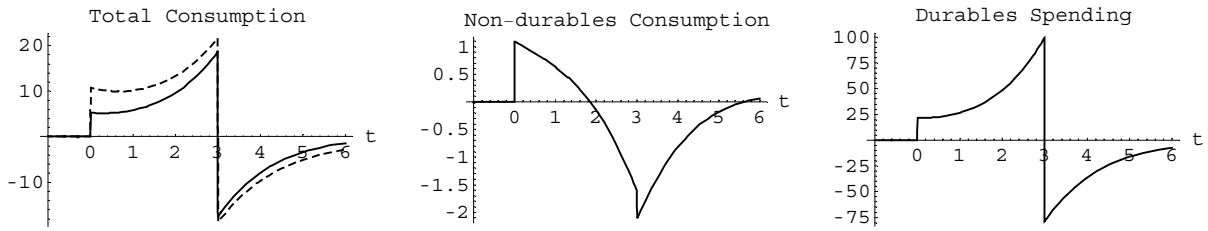


Panel C: τ = .50 and Ω = 5.

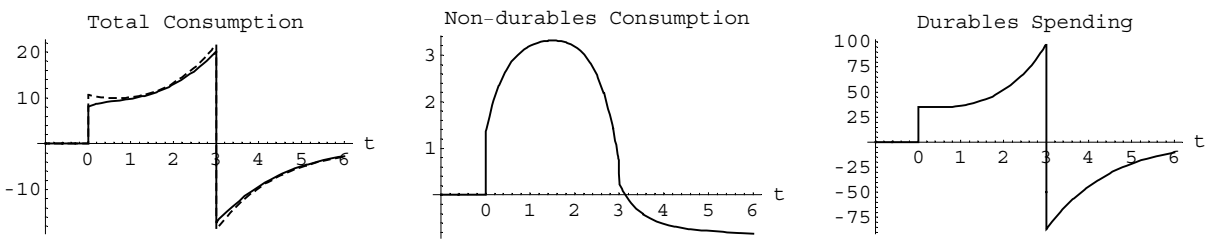


Panel D: τ = .50 and Ω = 10.

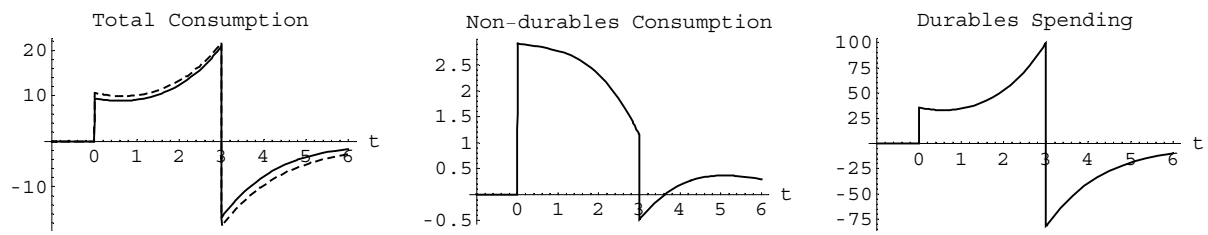
Figure 2: Transition path in the simple benchmark model.



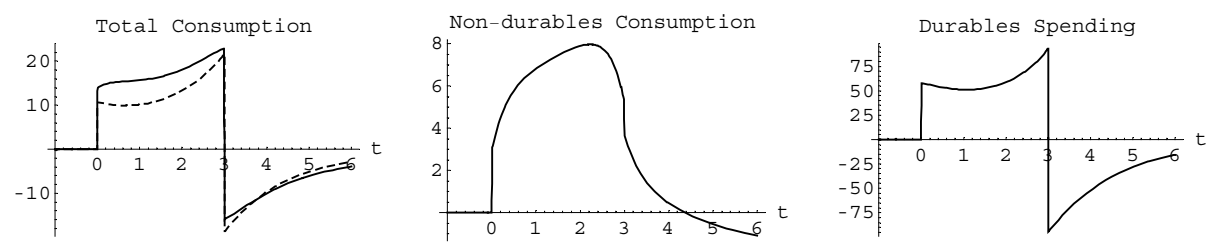
Panel A: Additive specification with v = .5.



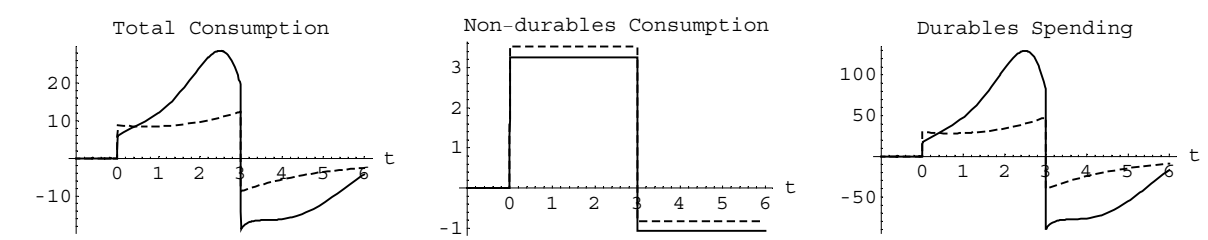
Panel B: Additive specification with v = 6.5.



Panel C: Multiplicative specification with v = .5.



Panel D: Multiplicative specification with v = 6.5.



Panel E: Habit formation affects deliberation costs (v = 3).

Figure 3: Transition path with alternative specifications of habit formation (--- is the path without habit formation).

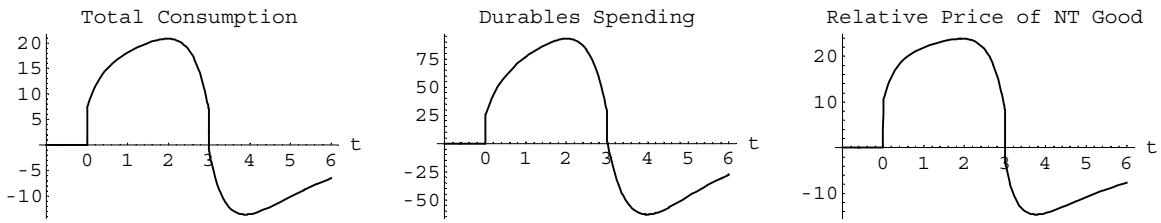


Figure 4a: Base run for temporary ERBS in the model with no supply effects.

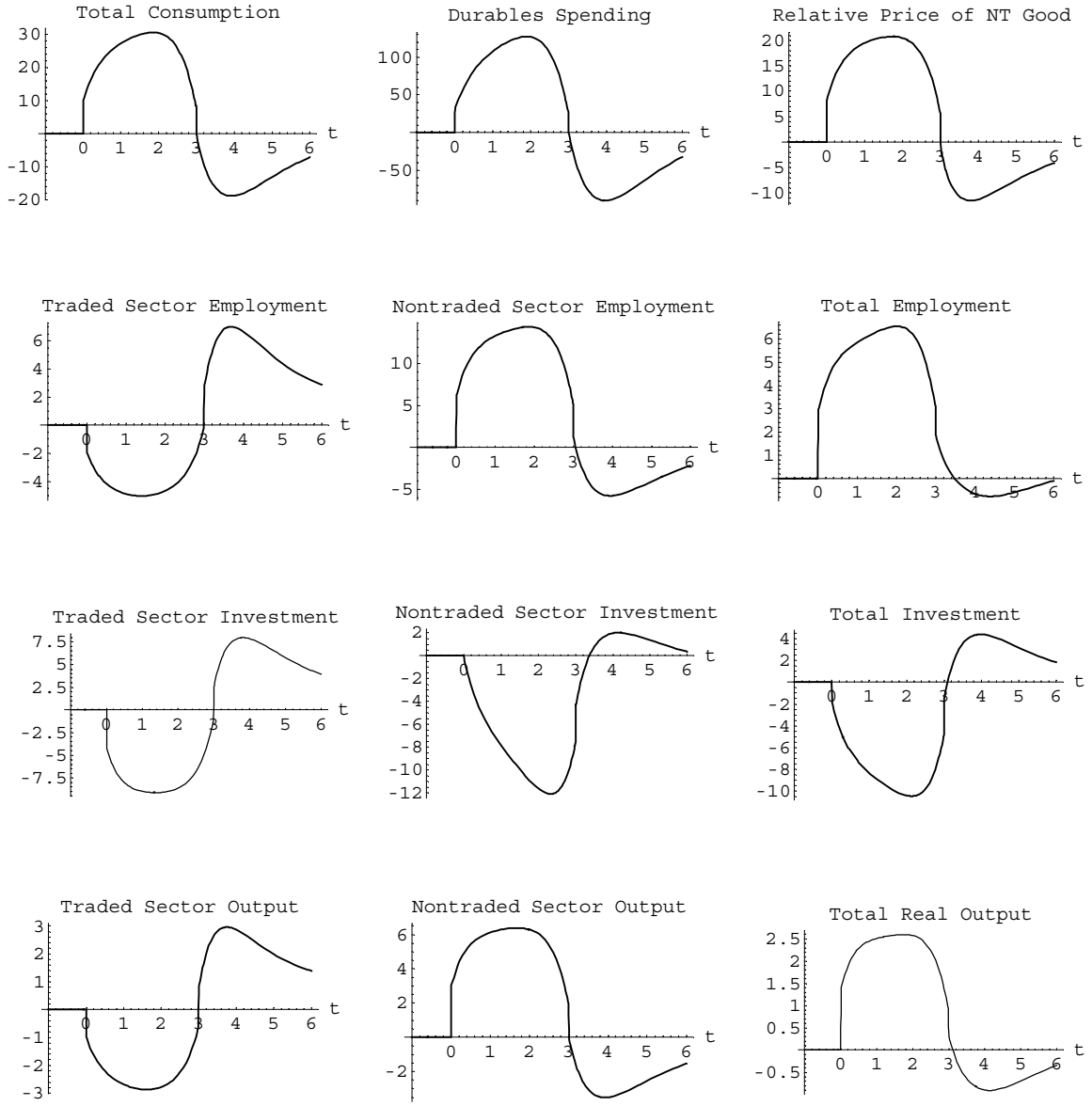


Figure 4b: Base Run for Temporary ERBS with supply effects
(q-elasticity of investment equals unity).

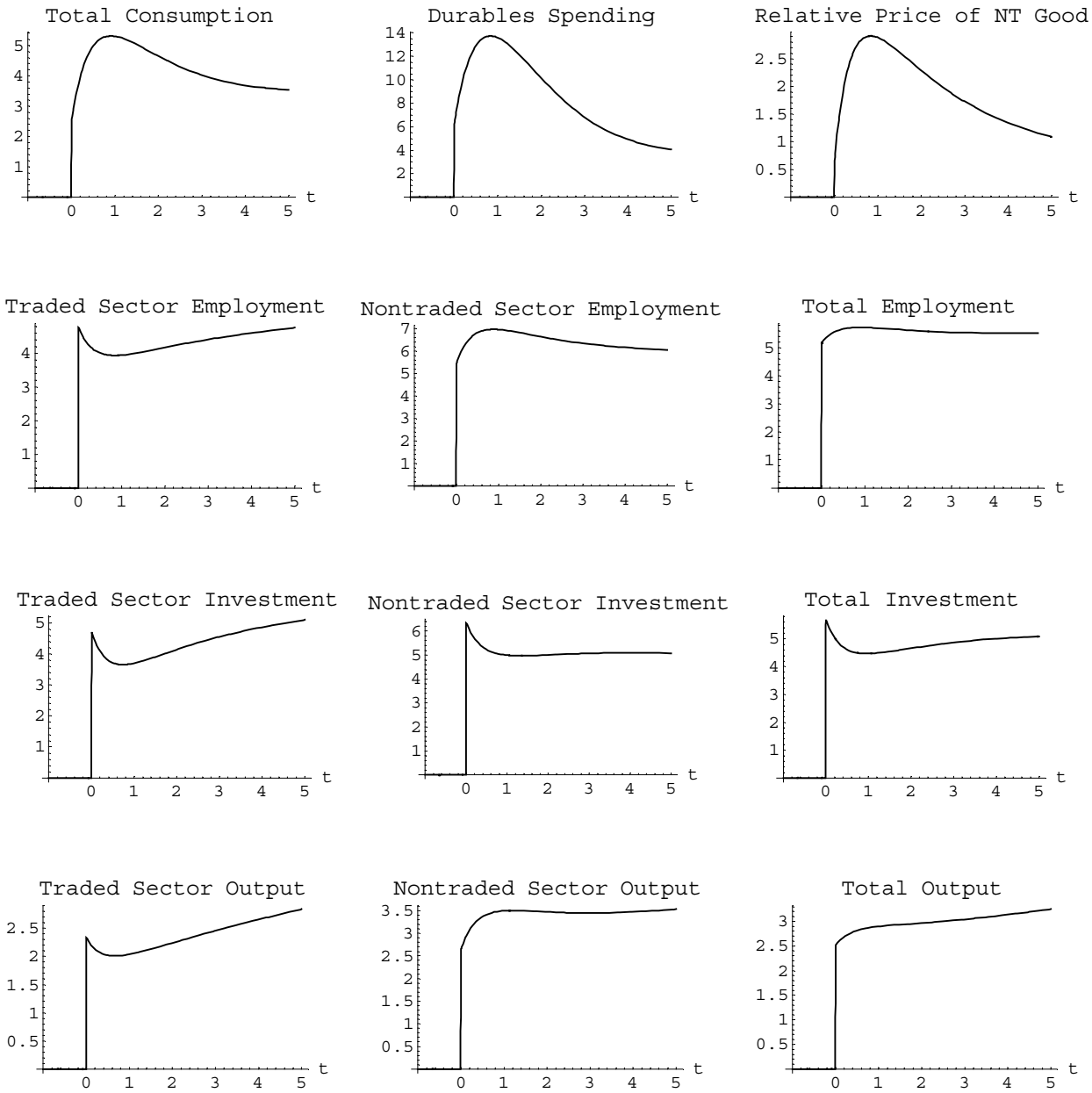


Figure 5: Base Run for Permanent ERBS with supply effects
(q-elasticity of investment equals unity).